Lackawanna Improvements at South Orange

Reinforced Concrete Flat Slab Construction Is Used in a Viaduct for Grade Separation and a New Station

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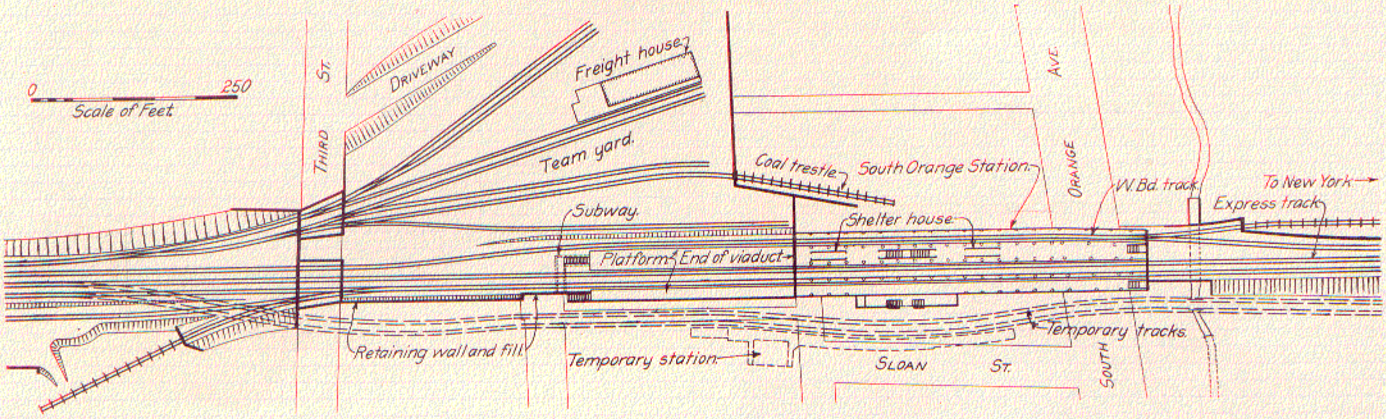
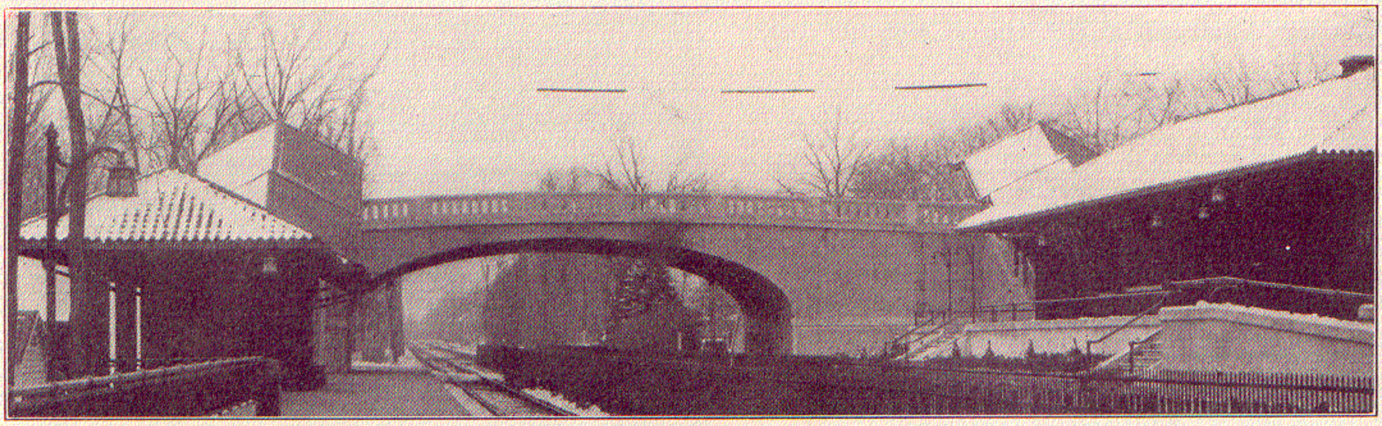
The Delaware, Lackawanna & Western in the past few years has made extensive improvements in the elimination of grade crossings and the construction of new stations on the Montclair branch and Morristown line of the Morris & Essex division. These lines are used almost exclusively for suburban service, carrying many thousands of commuters daily between New York City and suburban points in New Jersey within a radius of 30 miles of the metropolis. One of the most recent improvements is through South Orange, where the tracks have been elevated on an earth embankment for a distance of 5,000 ft. Four grade crossings were eliminated and new stations were built at Mountain station and South Orange. The same degree of permanence and architectural beauty that featured the structures on similar improvements at Montclair, Morristown and other points, has been maintained throughout this work.



Track Layout at South Orange Station

South Orange is 15 miles from New York and 6 miles from Newark, N. J. It is at the end of what might be termed the inner zone of suburban traffic. Many trains are made up at South Orange, where a round house and other facilities are provided. The improvement adds a third main or express track which has been in use for a considerable distance beyond South Orange and for part of the inner zone where the grade crossings have been eliminated. This track is operated eastbound in the morning and westbound in the evening, in the direction of the heavy travel. The important feature of the South Orange improvement is a reinforced concrete viaduct of cantilever flat-slab construction, designed to carry heavy locomotive loadings at high speeds, establishing a precedent, in all probability, for this type of construction, in the measure of its carrying capacity. This structure houses the South Orange station and also spans South Orange avenue.

The construction begins at Montrose avenue adjacent to Mountain station, 4,000 ft. east of South Orange station, where the tracks are maintained at their original grade and the avenue is carried overhead on a reinforced concrete arch.

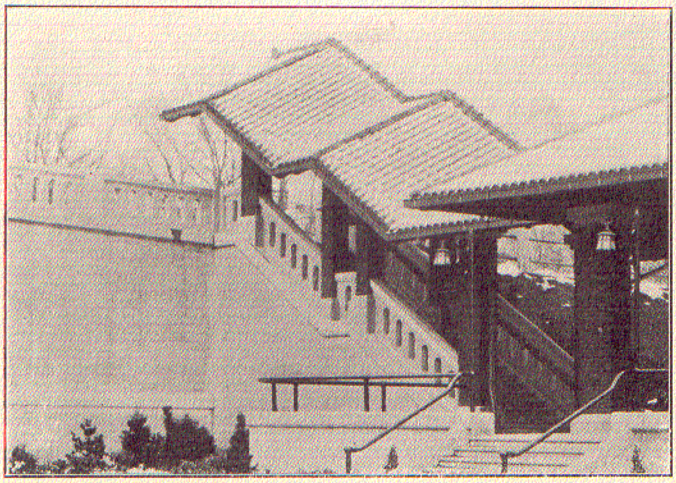


Montrose Avenue Arch and Mountain Station

This arch, which is shown in an accompanying photograph, was advantageously combined with the station layout by stairways to connect the station south of the tracks, with the shelter house north of them, thus furnishing a means for crossing the tracks and eliminating the usual subway construction. The bridge spans three tracks spaced 13 ft. center to center and two platforms 11 ft. 9½ in. in width, making a clear span of 60 ft. The arch is surmounted by an ornamental railing which is continued down the stairways leading to the station. The tile covered canopies over the concrete stairways are a continuation of the station and the shelter house roofs. The treatment combines the two structures and makes the arch an integral part of the station layout.

At a point 1,000 ft. west of Mountain station, the new tracks begin to ascend on a grade of 0.3 per cent, leaving the old tracks which were on a descending grade of approximately the same rate. This grade is continued to the easterly end of the viaduct at South Orange avenue, where it intersects a 0.25 per cent descending grade that extends across the structure. The latter grade is then increased to 1 per cent and joins the old tracks about one-half mile beyond the viaduct.

The elevation of tracks eliminated two other grade crossings besides that at South Orange avenue, i. e., Mead street, midway between Mountain station and South Orange, and Third street just west of the viaduct. It was necessary to depress these streets 7 and 4 ft. respectively, to obtain sufficient vertical clearance to construct reinforced concrete slab bridges. Both streets are 50 ft. in width, permitting of two 24-ft. spans supported along the center lines of the streets on 2-ft. piers with arched openings. The columns of each pier rest on a continuous reinforced footing of an in-



Architectural Treatment of Stairways at Mountain Station

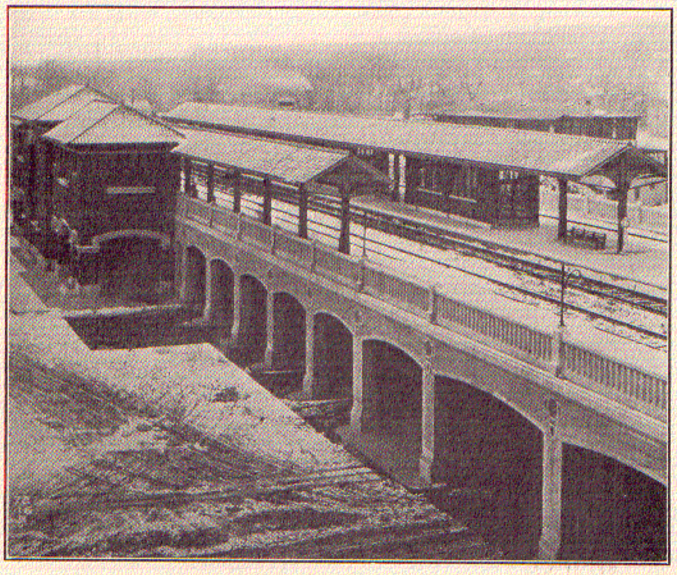
verted T-beam shape, the stem of which projects 6 in. above the crown of the road to form a curb and protection for the columns. The slab supporting the tracks has a depth of 3 ft. at the center of each span and the top has a pitch of 3 in. from the center of the pier to either abutment for drainage.

The Mead street bridge is a right-angle crossing, carrying three tracks and is 46 ft. wide. At Third street the construction consists of two separate bridges, 26 ft. apart. One supports the three main tracks similar to Mead street, while the other supports the tracks to the freight yards, as shown on the map.

The South Orange Viaduct

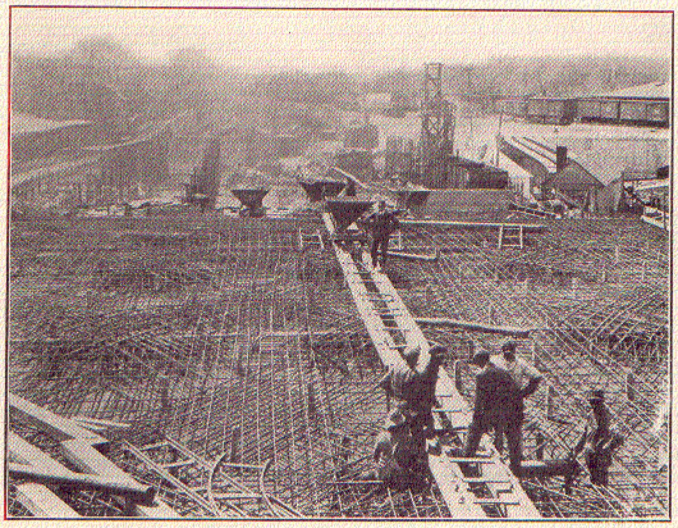
Owing to the exorbitant price wanted for property needed for the expansion of tracks and station facilities, it was decided to place the station under the tracks. The problem was solved economically by the construction of a reinforced concrete viaduct of cantilever flat-slab construction, 79 ft. wide and 426 ft. long, under which the station and all its appurtenances were built within the confines of the original right-of-way. The easterly end of the viaduct spans South Orange avenue, the main thoroughfare of the village. Other facilities provided under cover of the slab are, a concourse connecting the station with South Orange avenue, carriage space and a heating plant.

The reinforced concrete flat slab system carrying railroad loading was first used in the construction of the Soo Line terminal at Chicago and the satisfactory results obtained there prompted its adoption; first, for the construction of a viaduct, 150 ft. wide and 1,000 ft. long in the new Lackawanna terminal improvements now under construction at



South Orange Station

Buffalo, N. Y., and later for the South Orange viaduct. There are many advantages to be gained by this type of construction, aside from considerations of economy. It permits of effective architectural treatment, has a very shallow floor depth and like other slab construction it has no girders projecting above the deck to encroach upon the lateral clearances, or interfere, as in this case, with the construction of the platforms. The unbroken surface of the deck lends



Flat Slab Reinforcement, South Orange Viaduct

itself also to simple water-proofing treatments. The rigidity of the construction is noteworthy; two heavy locomotives passing over the structure at high speed, produce no noticeable vibration and rumbling noises, common to structural steel bridges, are very much subdued.

In addition to the three tracks, the viaduct carries an eastbound platform 15 ft. 4½ in. wide and a 25-ft. island platform between the middle or express track and the westbound local track. The 25-ft. width was fixed by clearance requirements on either side of the shelter houses built on this platform. The over-all width of the viaduct is 79 ft. for the portion extending from the west abutment to the westerly line of South Orange avenue at which point it was necessary to reduce the width of the structure to avoid the necessity of purchasing property on the east side of the avenue north of the viaduct. The width at the east abutment is 74 ft. 5 in.

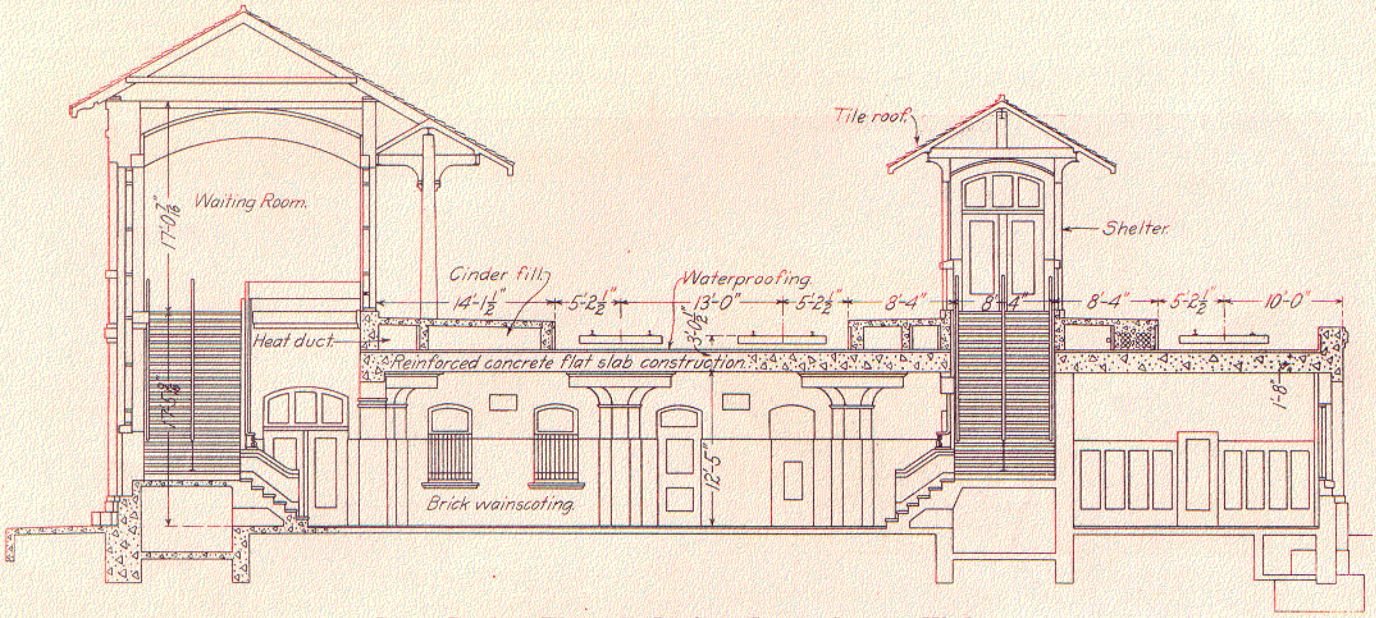
The transverse spacing of the columns, except at the narrowed end, is 18 ft. 9 in. center to center. This spacing is more economical than a 25-ft. spacing of a four-column bent. It also permits of the location of the island platform in the center of the second bay, so that the openings in the slab for stairways do not interfere with the direct bands of the reinforcing steel over the columns, at the same time giving a better distribution of the track loads.

Longitudinally the columns are spaced 20 ft. center to center from the west line of the avenue to the west abutment. At the avenue a change of the spacing of the columns was made necessary, owing to the width of the road-

faces, as well as the interior columns, were bush-hammered as a relief from the otherwise plain concrete.

It was at first planned to build the station and shelter houses on the upper level of concrete, but it was later decided to substitute the dark red wire-cut brick which produced so pleasing a contrast with the concrete at Mountain station. The brick, trimmed with concrete-stone, was laid in "double stretcher flemish bond," the double stretchers not being separated by mortar joints. The station interior was finished in plaster above a buff colored brick wainscoting, the plaster ceiling being applied directly to the concrete slab which had previously been coated with a binder of bituminous paint and sand. The baggage room, ticket office, lobby and other waiting room facilities are on the street level. Two sets of stairways lead from the lobby to the track level; one stairway to a waiting room on the eastbound side and the other to the island platform on which are two shelter houses. The platform canopies are built of structural steel with concrete roof slabs covered with the green tile.

The station and shelter houses are heated and ventilated by a hot-blast system, the heating plant being located on the south side of the viaduct adjacent to the west abutment, oc-



Cross Section Through Station, South Orange Viaduct

way and the angle of 81 deg. 40 min. that it makes with the center line of the express track. The length of the skew panels over the street is 30 ft. Since the remainder of the bents are at right angles to the center line of the express track, the panels adjacent to the roadway spans are of irregular dimensions. The east abutment span was made 23 ft. to permit of the location of the stairway openings that would not interfere with the reinforcing steel over the last row of columns. The columns for the typical 18 ft. 9 in. by 20 ft. panels are 34 in. in diameter. The columns along the curb line are 36 in. while those in the center of the roadway are 40 in. in diameter. The slab is 20 in. thick for the typical panel and is increased to 26 in. for the roadway span.

An effort was made to produce architectural effects in planning the viaduct and station. The type of railing used on the various bridges of this improvement and shown in the accompanying photographs, had its inception in the design of the viaduct and surmounts the entire structure. At both the north and south faces of the viaduct, half-round columns were completed by pilasters which were joined by flat segmental arches. Colored matt-glazed tile panels were inserted at the head of each pilaster and the exterior sur-

cupying the area of two panels. Part of this space is used as a coal bin which can be filled from hopper bottom cars by a chute through the abutment on the center line of the westbound track. The remainder of the space is devoted to the boiler and fan rooms. The boiler room floor is five feet below the street level and the fan is located above the boiler on a mezzanine floor. Reinforced concrete pipes were used for the ducts to carry the hot air underground to the station. A separate duct is carried through the slab and under the platforms to heat the shelter houses. A flue in the abutment leads to a chimney built on top of the wing wall retaining the approach fill.

Design

The cantilever flat slab system (patents for which are controlled by the Concrete Steel Products Company, Chicago) consists of a four-way reinforcement for the slab. Approximately one-half of the rods of each band are bent up and lapped over the column capitals to provide reinforcement for negative bending moment at these points. The effective depth at the columns is increased by drop panels which also serve to reduce the shearing stresses.

The structure was designed to carry two 233-ton Mikado

engines with drivers 5-ft. 6-in. center to center, 60,000-lb. axle loads, on each of the three tracks, with a live load impact factor of 68 per cent. of the static live load proportioned according to the following formula: $\text{Impact} = \frac{LL \times LL}{LL + DL}$.
The maximum negative and positive live load moments were determined by the theorem of three moments, for wheel concentrations of the two engines followed by a train load of 6,000 lb. perX lin. ft. of track over seven panels for both the irregular spans over the avenue and the 18-ft. 9-in. x 20 ft. 0-in. typical panels. For maximum moments all three tracks were considered loaded. In addition to the longitudinal continuity of the slab over the columns, there is a transverse continuity. However, the moments that were computed in the longitudinal direction were distributed transversely in accordance with the method of computing simple beam reactions and the impact factor determined by the formula mentioned above. Owing to the considerable amount of fixedness at the columns and the transverse continuity, 12/15 of the computed moment was used, thus giving end moments equivalent to $\frac{wL^2}{15}$ for determining the amount of steel required over the columns.

Following the method of calculating the negative moment over the columns, the slab at the center of the panel was proportioned for the maximum positive moment, reduced in the same ratio as was the negative moment. The reinforcement required was then distributed among the direct and diagonal bands in accordance with the co-efficients of 1/40 and 1/60 respectively, or a ratio of 3 to 2, as established by the Chicago building code.

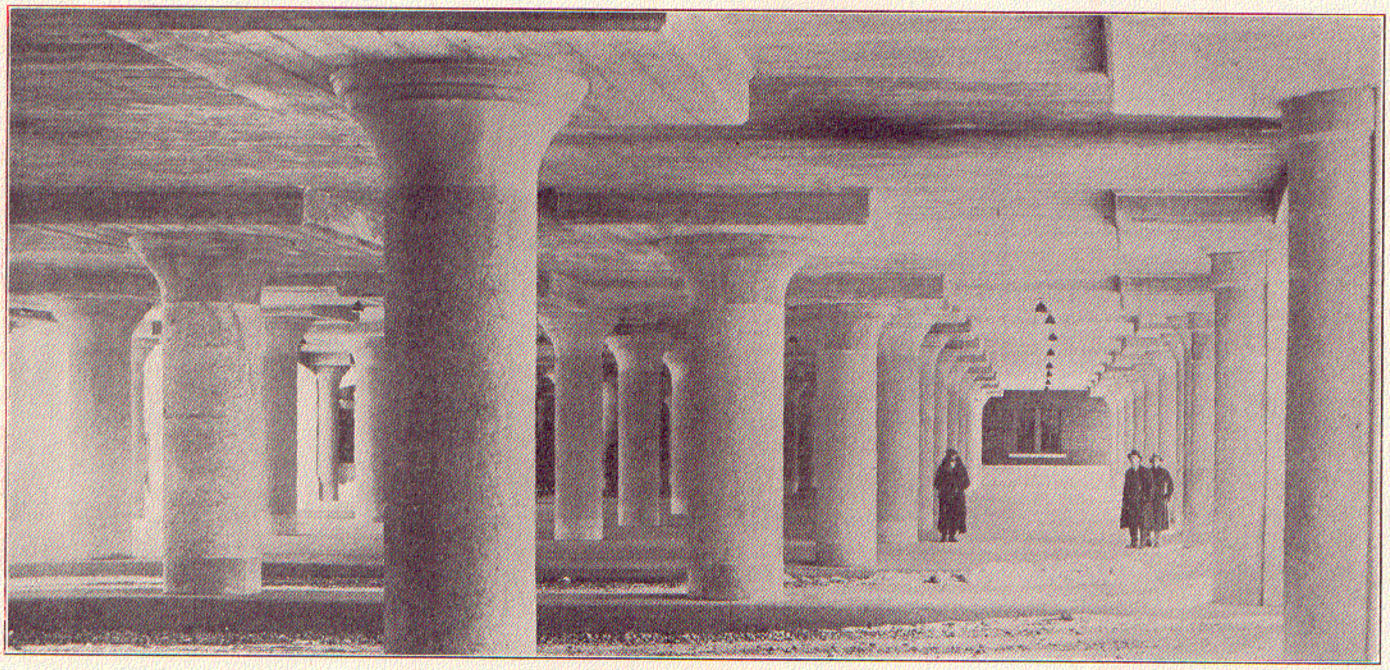
The columns were designed as hooped columns, with both spiral and vertical reinforcement to take the maximum reactions due to the conditions of loading as heretofore described. The footings of the two columns of each bent under the west bound track, are connected throughout by reinforced concrete ties to insure a more uniform distribution of the load on these footings. The footings are designed for a soil pressure of three tons per square foot on a good gravel subsoil, about five feet below the surface of the ground.

The unit stresses used in the design of this work were 650 lb. per sq. in. for extreme fiber compression in the concrete, 16,000 lb. per sq. in. for tension in the steel, and 500 lb. per sq. in. for concrete columns exclusive of the steel reinforcement.

The structure, 426 ft long, has no expansion joints. The slab is reinforced for stresses from temperature variations, by bands of reinforcing steel between each row of columns, both longitudinally and transversely. There are ten ¾-in. rounds in each longitudinal band and seven in each transverse band, spaced uniformly between the drop panels and placed in the upper plane of the slab. The bars of the four-way reinforcement, that are not bent up over the columns to resist the negative moment, are lapped to furnish continuous reinforcement which provides additional resistance to temperature changes. Additional temperature bars are placed around the stairway openings to bring the resistance of the reduced section to the same tensile strength as that of the full section.

Construction

As the entire improvement was along the old alignment, it was necessary to shift the tracks, as shown in the accompanying map to avoid delays to traffic. Property was leased where necessary, east of South Orange avenue and permission was obtained from the city to encroach somewhat on Sloan street for the temporary tracks and station.



View of Viaduct from the Underside

In constructing the footings for the columns, stubs or dowels projecting the required length, were imbedded to correspond to the vertical rods of the column reinforcement. The latter, including the spirals, were set in place and securely fastened to the stubs after which the falsework for the slab were erected. Sheet metal forms were used for the columns which were poured to an elevation about two inches above the underside of the drop-panels. The columns were allowed to attain an initial set before the slab was poured.

The bent-up bars of the slab reinforcement over the columns were held in place on a one-inch bar, circumferential around the edge of the drop panel in the upper plane, firmly supported by precast 4-in. by 4-in. concrete posts.

The slab was poured in three sections for the full width of the viaduct. To avoid construction joints in the slab through any part of the station, the last section was made 210 ft. long, covering 10½ panels and required 1,110 cu. yd. of concrete. This was the largest amount poured in a continuous operation.

Two mixtures were used to complete the work, one, a ¾-cu. yd. mixer, was stationary on the approach fill adjacent to the east abutment and the other of ½-cu. yd. capacity, mounted on a flat car, was moved ahead of the centering as the work progressed. For this purpose the old tracks approximately along the center line of the structure were not removed west of South Orange avenue until the structure was completed, and a connection was maintained with the temporary tracks during construction. The concrete was distributed from the mixers by buggies mounted on tracks raised above the level of the top of the slab. The tracks can be seen in one of the photographs.

In the construction of the stairs the concrete was first poured to within 2½ in. of the finished surface to allow for a concrete safety tread of that thickness. Alumdum, a mineral compound, was mixed with the concrete of the tread to form the resistive surface.

All abutments and retaining walls on this improvement were built in alternate sections not exceeding 30 ft. in length. Each section was poured in a continuous operation from the top of the footing to the underside of the coping to eliminate the usual unsightly horizontal joints where efflorescence is most likely to occur.

The entire area of the slab was waterproofed with three plies of Minwax saturated cloth laid in Minwax hard waterproofing, applied hot. The membrane under the platforms was protected by a 1½-in. layer of concrete, upon which the curbs and platforms supported on cinder fill were built. Under the tracks, the membrane was protected by two ¾-in. layers of asphaltic mastic mixed with torpedo washed gravel furnished by the Johns-Manville Company. The mastic was carried up the sides of the curb to form a trough.

Hyde, McFarlin & Burke, New York City, had the general contract for the improvement. The station, however, was built under separate contract by F. D. Hyde, of the same company. The design and construction of the South Orange improvement was carried out under the general direction of G. J. Ray, chief engineer of the Lackawanna. The station design and aesthetic features of the work were directed by F. J. Nies, company architect. G. T. Hand, division engineer, supervised the construction with W. H. Spiers, resident engineer, in immediate charge. The reinforced concrete design was directed by the writer, with the design of the flat slab construction, subject to the approval of the Concrete Steel Products Company.

CAMPAIGN TO INCREASE CAR LOADING ON THE CHICAGO & NORTH WESTERN

For the past two years the Chicago & North Western has been engaged in a systematic campaign to bring about a more efficient use of its equipment by securing heavier loading of its freight cars.

For several years the management has been making an effort to impress upon agents the importance of heavier loading of cars and general instructions have been issued, with the result that the car loading has been progressively increased, but the best results were not obtained until a systematic campaign of education and supervision was inaugurated under the direction of the vice-president in charge of operation. During the past two years, however, the efforts in this direction have been attended with such successful results that an examination of the methods that have been pursued is of special interest at this time when the country is experiencing a car shortage, the largest ever reported for this period of the year since 1907.

As the loading of carload freight is done by the shipper and is not under the direct control of the railroads this campaign has necessarily consisted mainly of work among the shippers. In explaining to them the advantages of utilizing the full capacity of freight equipment, not only from the standpoint of the railroads, but from the standpoint of the shippers and consignees themselves, during the past two years the superintendents, trainmasters and traveling agents of the traffic department of the North Western have personally visited every shipper on the line of the road. Moreover, this work has been backed up by constant and thorough supervision on the part of the operating department officials, and by a willingness to co-operate with the shippers in securing the desired results. In case a shipper overloads a car inadvertently he is not penalized, but the railroad assumes the cost of transferring the load.

At the outset the company was confronted with the fact that the minimum carload weight as prescribed in the tariffs, and in many cases fixed by orders of the federal or the state commissions, are very much below the capacity of the cars, and that many shippers are inclined to order at one time only a sufficient quantity to give them the benefit of the minimum carload freight rate, in order to reduce their investment in stock carried or for other reasons. This condition has been met, however, by showing the shippers and consignees the benefit to themselves in addition to the benefit to the railroads, which would be derived from handling shipments in as large quantities as possible, and increasing the efficiency of the available equipment, thus lessening the liability of a car shortage, and by avoiding the inconveniences, loss of business, or even more serious consequences attendant upon inability to receive desired shipments promptly in times of car shortage or of severe weather.

For the purpose of ascertaining specific cases of light loading of equipment in order that they might be brought to the attention of the railroad officials and the shippers, a man was stationed in the freight auditor's office, reporting to the vice-president's office to check over all waybills. For this purpose a man was employed who had formerly been a yard clerk and who was therefore familiar with the capacity of cars and the conditions affecting the loading of commodities. This man receives all waybills and when he finds an instance in which a car has been loaded to very much less than its full capacity he checks off the information called for by the following blank:

		Division.
Car	Date	Waybill
Contents	Shipper	
From	To	
Capacity	Wt. of Contents	Lbs. Underloaded

He checks especially the billing from coal loading docks, elevators, etc., and tries to secure evidence of several cars from one consignor to one consignee. The blank is then sent to the agent at the point of shipment with instructions to call on the shipper and bring the matter to his attention. In the case of shipments of several cars from one consignor to one consignee he is given information as to how many more cars were used than would have been necessary if they had been loaded to capacity. The agent explains in detail the advantages on both sides of loading cars to capacity and urges the shipper to order in carload lots whenever possible. If he is informed that the tonnage was specified by the consignee the information is sent to the agent at the point of destination, who calls on the consignee.

The agents are instructed to bring to the attention of shippers at every opportunity the advantages of capacity loading and to make every effort in their power to secure heavier loading.

Detailed instructions on this point were issued in a circular to agents dated December 19, 1914, signed by the